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(54) **SYNTHESE DU 2-(METHYL-SULFONYL)-5-  
(TRIFLUOROMETHYLE)-1,3,4-THIADIAZOLE PAR  
L'OXYDATION DE 2-(METHYLTHIO)-5-  
(TRIFLUOROMETHYLE)-1,3,4- THIADIAZOLE AVEC UN  
CATALYSATEUR DE MOLYBDENE OU DE TUNGSTENE**  
(54) **SYNTHESIS OF 2-(METHYL-SULFONYL)-5-  
(TRIFLUOROMETHYL)-1,3,4-THIADIAZOLE VIA  
OXIDATION OF 2-(METHYLTHIO)-5-  
(TRIFLUOROMETHYL)-1,3,4-THIADIAZOLE WITH A  
MOLYBDENUM OR TUNGSTEN CATALYST**

(57) The present invention provides processes of making thiadiazole sulfone. The present processes are used to make 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole. The 2-(methylsulfonyl)-5-(trifluoro-methyl)-1,3,4-thiadiazole is made using catalytic oxidation in the presence of a suitable oxidizing agent. The catalyst used for the oxidation reaction is a molybdenum or tungsten catalyst.



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SYNTHESIS OF 2-(METHYLSULFONYL)-5-(TRI-  
FLUOROMETHYL)-1,3,4-THIA DIAZOLE VIA OXIDATION  
OF 2-(METHYLTHIO)-5-(TRIFLUOROMETHYL)-1,3,4-THIA-  
DIAZOLE WITH A MOLYBDENUM OR TUNGSTEN CATALYST

ABSTRACT OF THE DISCLOSURE

The present invention provides processes of making thiadiazole sulfone. The present processes are used to make 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole. The 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole is made using catalytic oxidation in the presence of a suitable oxidizing agent. The catalyst used for the oxidation reaction is a molybdenum or tungsten catalyst.

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FLUOROMETHYL)-1,3,4-THIA DIAZOLE VIA OXIDATION  
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DIAZOLE WITH A MOLYBDENUM OR TUNGSTEN CATALYST

TECHNICAL FIELD OF THE INVENTION

The field of the present invention is the synthesis of thiadiazole sulfones. More particularly, the present invention pertains to the synthesis of 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole using  
5 catalytic oxidation.

BACKGROUND OF THE INVENTION

Sulfones have the general structure  $RR'SO_2$ . Sulfones can be produced from a variety of precursors. By way of example, sulfones can be prepared by (a) oxidizing sulphides, (b) rearranging sulphinate esters,  
10 (c) adding sulfonyl halides to alkenes and acetylenes, (d) adding sulphinic acids to polarized bonds, and (e) adding (cyloaddition) of  $SO_2$  to polyenes (See, e.g., Durst, T., in Comprehensive Organic Chemistry: Chapter 11.6, Barton and Ollis, Eds., Pergammon Press, Oxford, 1979).

A particular class of sulfones, 2-(alkylsulfonyl)-1,5-(trifluoromethyl)-  
15 1,3,4-thiadiazoles are intermediates used in the production of herbicides. 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole has been reported to possess antifungal activity (See, U.S. Patent 3,562,284). According to U.S. Patent 3,562,284, 2-(substituted sulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazoles can be made by oxidizing a corresponding 2-(substituted  
20 thio)-5-(trifluoromethyl)-1,3,4-thiadiazole in the presence of an oxidizing agent such as potassium permanganate, hydrogen peroxide or peroxytrifluoroacetic acid. Oxidation takes place in an acidic, aqueous medium that includes acetic acid and methylene chloride as a solvent. Methylene chloride is an undesirable solvent from the standpoint of  
25 industrial hygiene and handling. It is difficult to handle due to the low boiling point (high vapor pressure) and it also contaminates aqueous

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waste streams. The sulfone product is isolated using crystallization. The reported yield of the sulfone, based on the starting sulfide, was about 65%.

The use of acetic acid in the presence of water in the process necessarily introduces excess water into the reaction and requires purification of the sulfone using expensive crystallization procedures with resultant low yields. There continues to be a need in the art for a practical, inexpensive process for preparing thiadiazole sulfones in high yield.

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### BRIEF SUMMARY OF INVENTION

The present invention provides a process for making 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole. The process includes the step of oxidizing 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole in a reaction mixture containing an activated molybdenum or tungsten catalyst to form a reaction product. In one embodiment, 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is reacted with hydrogen peroxide in the presence of the activated catalyst. Preferably, the 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is dissolved in an aprotic, aromatic solvent such as toluene.

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The activated catalyst is molybdic acid or tungstic acid. Such an acid can be directly added to the reaction mixture or can be formed in the reaction mixture from tungstate or molybdate salts. The acid is preferably formed by acidifying an alkali metal molybdate or tungstate salt. A preferred alkali metal is sodium and a preferred acid for acidification is sulfuric acid. Formation of the activated catalyst can take place in the mixture. In accordance with this embodiment, 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is reacted with hydrogen peroxide in the presence of the alkali metal salt and sulfuric acid.

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The hydrogen peroxide used in the reaction mixture is preferably an aqueous solution containing from about 30 weight percent to about 50

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weight percent hydrogen peroxide. The activated catalyst is present in an amount of from about 0.5 grams to about 10 grams of catalyst per mole of 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole. Oxidation typically occurs at a temperature of from about 50°C to about 100°C and, preferably at a temperature of from about 70°C to about 90°C.

The process of the present invention can include additional steps. Unspent catalyst can be recovered and the recovered catalyst optionally recycled into the reaction mixture. Further, water can be removed from the reaction product. The removal of water is preferably accomplished azeotropically. Still further, a process of this invention can include the step of isolating the formed 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole.

#### DETAILED DESCRIPTION OF THE INVENTION

##### I. The Invention

The present invention provides the process for producing thiadiazole sulfone. The present processes are used to make 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole (TDA sulfone) from 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole (TDA). TDA sulfone is made using catalytic oxidation of TDA in the presence of a suitable oxidizing agent. The catalyst used for the oxidation reaction can be a molybdenum, tungsten, or boron catalyst or glacial acetic acid.

##### II. Process for Producing TDA Sulfone Using Tungsten or Molybdenum

In accordance with this aspect, the present process includes the step of oxidizing 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole (TDA) in a reaction mixture containing an activated molybdenum or tungsten catalyst to form a reaction product that contains the TDA sulfone product. Oxidation of TDA takes place in the presence of a suitable oxidizing agent. Exemplary such oxidation agents are well known in the art (See, e.g., Durst, T., in Comprehensive Organic Chemistry: Chapter 11.6,

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Barton and Ollis, Eds., Pergammon Press, Oxford, 1979). A particularly preferred oxidizing agent is hydrogen peroxide ( $H_2O_2$ ). In accordance with this embodiment, TDA is reacted with hydrogen peroxide in the presence of a catalyst. The hydrogen peroxide used in the reaction mixture is preferably an aqueous solution containing from about 30 weight percent to about 50 weight percent hydrogen peroxide. The molar ratio of  $H_2O_2$  to TDA is from about 2:1 to about 4:1 and, preferably about 2.2:1. Oxidation conditions are well known in the art. Typically, oxidation is carried out at a temperature of from about 60°C to about 100°C.

TDA used in a present process can be obtained from any source. Preferably, the TDA is made by a process that provides TDA in an aprotic, aromatic solvent such as toluene. Especially preferred means for making TDA can be found in the U.S. Patent Applications entitled "A Process for Making 2-(Methylthio)-5-(Trifluoromethyl)-1,3,4-Thiadiazole Using Methyldithiocarbazine and a Molar Excess of Trifluoroacetic Acid", "A Process of Making 2-(Methylthio)-5-(Trifluoro-methyl)-1,3,4-Thiadiazole Using Methyldithiocarbazine with Trifluoro-acetic Acid with Removal of Bis-Byproduct", and "A Process for Preparing 2-(Methylthio)-5-(Trifluoromethyl)-1,3,4-Thiadiazole Using Methyldithiocarbazine and a Molar Excess of Trifluoroacetic Acid With Recovery of Trifluoroacetic Acid", filed concurrently herewith. The disclosures of all three applications are incorporated herein by reference.

The oxidation of TDA occurs in the presence of a solvent. Preferably, the solvent is an aprotic, aromatic solvent. Such solvents are well known in the art. Exemplary and preferred such solvents are toluene, xylene, cumene and mesitylene. Toluene is especially preferred. The amount of solvent used can vary over a wide range as readily determined by a skilled artisan. The precise amount of solvent will depend on the particular solvent used. Where toluene is the solvent, it is present in an amount from about 0.5 moles to about 3.5 moles of toluene



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per mole of TDA. Preferably, toluene is present in an amount of from about 1.0 moles to about 2.0 moles per mole of TDA and, more preferably, in an amount of from about 1.0 to about 1.5 moles of toluene per mole of TDA.

- 5           The term "activated catalyst" as used herein means molybdic acid or tungstic acid. Such acids include acid salts such as ammonium tungstate or ammonium molybdate. The activated catalyst is present in an amount of from about 0.005 to about 0.035 moles of catalyst per mole of TDA. Preferably, the molar ratio of catalyst to TDA is about 0.015:1.
- 10       Such an acid can be directly added to the reaction mixture or can be formed in the reaction mixture from tungstate or molybdate salts. The acid is preferably formed by acidifying an alkali metal molybdate or tungstate salt. Exemplary and preferred such alkali metal salts are well known in the art and are commercially available. Especially preferred
- 15       alkali metal salts are sodium, potassium and lithium salts of tungstic or molybdic acid. Sodium salts such as  $\text{Na}_2(\text{MoO}_4)$  and  $\text{Na}_2(\text{WO}_4)$  are most preferred.

          The activated catalyst is formed by acidifying the alkali metal salt with an acid. Exemplary and preferred acids are inorganic acids having a

20       pKa between about 1 and 4. Especially preferred acids are hydrochloric acid, sulfuric acid and nitric acid. Sulfuric acid ( $\text{H}_2\text{SO}_4$ ) is most preferred. Formation of the activated catalyst can take place in the oxidation reaction mixture itself. In accordance with this embodiment, TDA is reacted with hydrogen peroxide in the presence of the alkali metal salt

25       and acid.

          Even where the acid catalyst (e.g., molybdic acid) is added directly to the reaction mixture, the reaction mixture can further contain additional acid. That acid can be an inorganic acid as set forth above or trifluoroacetic acid. The acid is present in an amount of from about 0.01 to

30       about 0.03 moles per mole of TDA.

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A process for the present invention as set forth in Section II above, can include additional steps. The catalyst can be recovered and the recovered catalyst optionally recycled into the reaction mixture. Further, water can be removed from the reaction product. Still further, a process  
5 of this invention can include the step of isolating the formed sulfone.

Water removal is preferably accomplished azeotropically. The azeotropic removal of water is readily accomplished in the presence of the solvent, particularly where the solvent is toluene. Because the azeotrope has a lower boiling point than water, heating the reaction  
10 product to the boiling point of the solvent effectively removes the water. Because the oxidation reaction occurs in the range of about 60°C to about 85°C, water is removed during the reaction; no additional step is required.

The following examples illustrate preferred embodiments of the  
15 present invention and are not limiting of the specification and claims in any way.

### EXAMPLES

#### Example 1: Synthesis of TDA Sulfone Using A Molydenum Catalyst

5 grams of sodium molybdate monohydrate and 2 grams of  
20 concentrated  $H_2SO_4$  were added to a solution of 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole (TDA) (202.6 g of 98.8% purity, 1.0 mole) in toluene (116.2 g) with stirring. The mixture was heated to 80° with stirring. A 35 weight percent  $H_2O_2$  solution in water (260 g; 2.67 mole) was added uniformly over 4 hours. During the addition of  $H_2O_2$ ,  
25 the reaction temperature was maintained at 80±2°.

The reaction mixture was cooked at 80°C until mono-oxidized species of TDA were less than 1% (as analyzed by gas chromatography) (approx. 2-3 hours). Water was removed azeotropically with toluene. The reaction mixture was diluted with about 225 grams of toluene and

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the solid filtered out at 60°C using steam jacketed suction filtration. The TDA sulfone was isolated from the filtrate (purity 98%, net yield 95.5%).

A. Recycle of Catalyst

- The filtered out solid from above and 2.0 grams concentrated
- 5 H<sub>2</sub>SO<sub>4</sub> was added to a solution of TDA (202 g of 98.8% purity; 1.0 mole) in toluene (116.2 g) with stirring. 35% aqueous H<sub>2</sub>O<sub>2</sub> (260 g; 2.67 mole) was added uniformly over 4 hours. During the addition of H<sub>2</sub>O<sub>2</sub>, the temperature was maintained at 80±2°C. The reaction mixture was cooked at 80°C until the mono-oxidized species of TDA was less than 1% (as
- 10 analyzed by gas chromatography) (approx. 2-3 hours).

- Reaction water was removed azeotropically with toluene. The reaction mixture was then diluted with about 225 grams of toluene and the solids filtered out at 60°C using suction filtration. The cake was saved for recycle. The TDA-sulfone was isolated from the filtrate (purity
- 15 98.1%, net yield 98%). The sodium molybdate catalyst can be used in the molar ratio of 3-5 grams of catalyst per mole TDA.

B. Use of Sulfuric Acid

- In another series of studies, 5 grams of molybdic acid, in the absence or presence of H<sub>2</sub>SO<sub>4</sub>, was used as a catalyst. Catalyst was
- 20 recycled numerous times. Subsequent recycles were done using molybdic acid and H<sub>2</sub>SO<sub>4</sub> from the preceding run. The reaction conditions and the stoichiometry used in each series were as follows:

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		Series A (no H <sub>2</sub> SO <sub>4</sub> )	Series B (with H <sub>2</sub> SO <sub>4</sub> )
	Molybdic acid	5 g	5 g
	Conc. H <sub>2</sub> SO <sub>4</sub>	—	3.75 g
	Conc of TDA in toluene	60%	60%
5	TDA	1 mol	1 mol
	Reaction Temperature	80°C	80°C
	H <sub>2</sub> O <sub>2</sub> Add Time	3 hrs	3 hrs
	Cook Time (<1% sulfoxide)	2-3 hrs	2-3 hrs
10	Excess H <sub>2</sub> O <sub>2</sub>	30-60%	30-60%

Water was azeotropically removed from the reaction product. The organic layer was diluted down to 40% TDA-SO<sub>2</sub> in toluene from 60% TDA-SO<sub>2</sub> in toluene. The analytical results are summarized below:

		%Sulfone	% NetYield	% Sulfoxide
15	Series A (Molybdic acid alone)	98.6	94.9	0.6
	Series B (Molybdic acid + H <sub>2</sub> SO <sub>4</sub> )	96.8	91.7	0.5

#### 20 C. Use of Ammonium Molybdate

Two TDA-sulfone batches (original + 1 recycle) were made using ammonium dimolybdate as the catalyst. Ammonium dimolybdate is the major constituent of molybdic acid. The physical and chemical characteristics of the oxidation reactions were identical with that of reactions using molybdic acid as the catalyst. The net yields using ammonium molybdate were both in the 98-99% range.

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Example 2: Synthesis of TDA Sulfone Using Tungsten Catalyst

TDA in toluene and sodium tungstate ( $\text{Na}_2\text{WO}_4$ ) were charged in a reaction vessel. The catalyst was either fresh or recycled from a previous reaction batch. The mixture was heated to the reaction start temperature. 35 weight percent  $\text{H}_2\text{O}_2$  was added over time. The reaction mixture was then heated to the reaction temperature for 2-3 hours. The mixture was  $\text{N}_2$  purged during the reaction. Reaction conditions were as follows:

	TDA/Toluene, wt. % TDA	57-60
10	Reaction start temp, °C	70-74
	$\text{H}_2\text{O}_2$ /TDA Mole Ratio	2.30-2.40
	$\text{H}_2\text{O}_2$ add time, hrs	3.0-3.5
	Reaction temp, °C	80-90
	Reaction time, hrs	2.0-3.0

- 15        The reaction product mixture was then heated to reflux and some water was removed by azeotropic distillation. The mixture was cooled to 70°C and the phases are separated.

The aqueous catalyst phase was retained for recycle to the next batch. The TDA sulfone/toluene phase was retained for subsequent use.

- 20        The average net yield for the sodium tungstate process was about 97.5%.

- 25        Although the invention has been described in detail in the foregoing for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention except as it may be limited by the claims.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:-

1. A process for making a 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole comprising oxidizing 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole in a reaction mixture containing an  
5 activated molybdenum or tungsten catalyst to form a reaction product.
2. The process of Claim 1 wherein 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is reacted with hydrogen peroxide in the presence of the activated catalyst.
3. The process of Claim 1 wherein 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is dissolved in an aprotic, aromatic  
10 solvent.
4. The process of Claim 3 wherein the solvent is toluene.
5. The process of Claim 2 wherein the activated catalyst is a molybdic or tungstic acid.
6. The process of Claim 5 wherein the molybdic acid is formed  
15 by acidifying an alkali metal molybdate salt.
7. The process of Claim 6 wherein the alkali metal molybdate salt is acidified with sulfuric acid.
8. The process of Claim 7 wherein 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is reacted with hydrogen peroxide in the  
20 presence of sodium molybdate and sulfuric acid.
9. The process of Claim 5 wherein the tungstic acid is formed by acidifying an alkali metal tungstate salt.
10. The process of Claim 9 wherein the alkali metal tungstate  
25 salt is acidified with sulfuric acid.
11. The process of Claim 10 wherein 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole is reacted with hydrogen peroxide in the presence of sodium tungstate and sulfuric acid.
12. The process of Claim 1 wherein the activated catalyst is  
30 ammonium molybdate or ammonium tungstate.

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13. The process of Claim 1 further comprising the step of recovering catalyst.

14. The process of Claim 13 wherein recovered catalyst is recycled into the reaction mixture.

5 15. The process of Claim 1 wherein oxidation occurs at a temperature of from about 50°C to about 100°C.

16. The process of Claim 15 wherein the temperature is from about 70°C to about 90°C.

10 17. The process of Claim 2 wherein the hydrogen peroxide is an aqueous solution containing from about 30 weight percent to about 50 weight percent hydrogen peroxide.

18. The process of Claim 1 wherein the activated catalyst is present in amount of from about 0.5 grams to about 10 grams of catalyst per mole of 2-(methylthio)-5-(trifluoromethyl)-1,3,4-thiadiazole.

15 19. The process of Claim 2 further comprising azeotropically removing water from the reaction product.

20. The process of Claim 1 further comprising recovering the formed 2-(methylsulfonyl)-5-(trifluoromethyl)-1,3,4-thiadiazole.